

PFOS and PFOA in Humans

New Study Links Prenatal Exposure to Lower Birth Weight

Scientists have accumulated a wealth of evidence that perfluorooctane sulfonate (PFOS) and perfluorooctanoate (PFOA, also known as perfluorooctanoic acid) accumulate in the environment and humans. Animal studies have shown these compounds to cause a variety of health effects, including reduced birth size and infant mortality. Now researchers are presenting the first evidence to suggest that human exposure to the chemicals is linked to reduced birth weight [*EHP* 115:1670–1676; *Apelberg et al.*].

PFOS, PFOA, and related polyfluoroalkyl compounds (PFCs) that can be transformed into these chemicals in the environment are used in a wide range of consumer applications, including oil and water repellents for fabric, apparel, and carpets, and paper coatings such as fast-food wrappers. The chemicals have been found in the blood of people throughout the world.

The new study shows that infants born with higher concentrations of PFOS and/or PFOA in their umbilical cord serum (a measure the researchers used as a marker of *in utero* exposure) had lower birth weights. The authors calculate the reduction as –69 g for PFOS and –104 g for PFOA. The study population included 293 infants born in Baltimore, Maryland, in 2004 and 2005. In earlier research, PFOA had been found in all these infants, and

PFOS had been found in 99% of them. Infants with higher levels of PFOS and PFOA also had smaller head circumferences and lower scores on the ponderal index, a measure of body mass at birth. The study was not designed to allow the cohort to be followed in the future.

The results are consistent with those of toxicologic studies conducted with mice and rats that also have linked exposure to PFOS and PFOA with low birth weight—albeit at doses that resulted in much higher body burdens than those seen in the Baltimore infants. Both compounds have also been tied to developmental delays in animal studies. Previous studies in humans have correlated low birth weight with obesity, diabetes, and cardiovascular diseases later in life.

The researchers stress that the effect was small but statistically significant. They also note that the concentrations of PFOS, PFOA, and other PFCs in the infants' blood were relatively low compared with levels tested in other studies.

The results were statistically adjusted to consider other potential sources of altered birth weight, such as maternal smoking, diabetes, and hypertension. The new study did not find a correlation between levels of the compounds and socioeconomic status, as had previous research. The researchers also found no evidence of an association between the infants' exposure to the chemicals and their cholesterol or triglyceride levels, despite previous human and animal studies suggesting that these blood lipids are particularly sensitive to PFC exposure. —**Kellyn Betts**

VOCs Turn Up in Well Water

Sensitive Measure Reveals Groundwater Contaminant

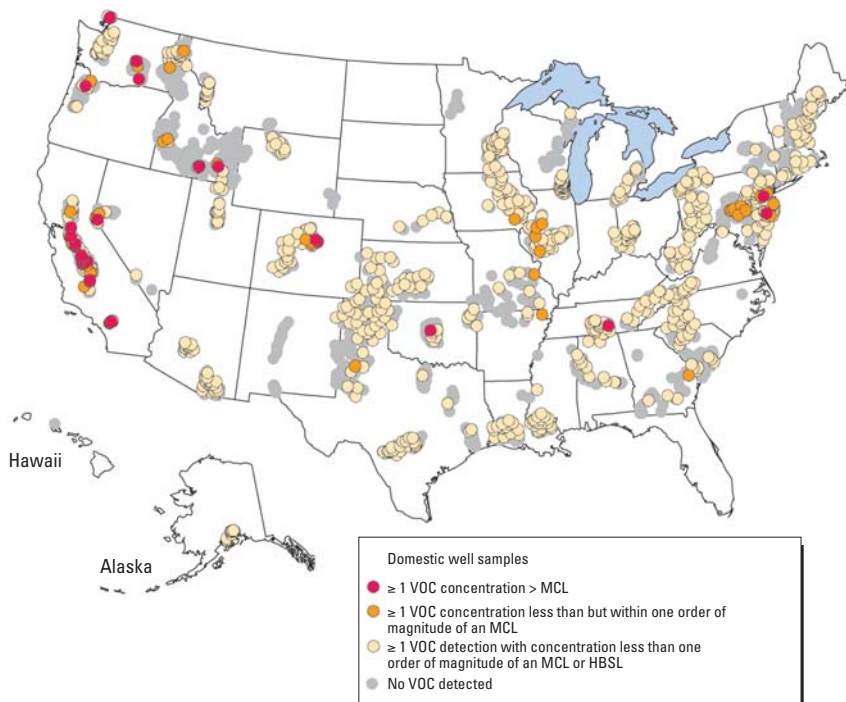
About 15% of the U.S. population get their drinking and household water from a largely unmonitored source: private residential

wells. About 400,000 new wells are drilled every year. A new USGS study suggests that the water in a small percentage of domestic wells could contain unsafe levels of volatile organic compounds (VOCs) [*EHP* 115:1539–1546; *Rowe et al.*].

VOCs come from a wide variety of sources, including gasoline, plastics, paints, dyes, solvents, adhesives, insecticides, and spot removers, and have wide-ranging health effects. The chemical and physical properties of VOCs allow the compounds to move between the atmosphere, soil, surface water, and groundwater. Once in the environment, some VOCs degrade quickly whereas others persist for decades.

The USGS collected data on 55 VOCs primarily between 1991 and 2002. The team analyzed water samples before homeowners treated or filtered the water, which could help reduce VOCs. Many—possibly half of all well users—don't filter their water. The wells ranged in depth from 6 to 1,500 feet, with a median depth of about 140 feet. Of the 2,401 wells studied, 65% had detectable levels of VOCs, and 1% had levels above the EPA maximum contaminant level for the compound(s) observed. The most common compounds found were chloroform, toluene, 1,2,4-trimethylbenzene, and perchloroethene.

Factors associated with the presence of VOCs were dissolved oxygen content, precipitation, the presence of a hazardous waste site within 1 km of the well, aquifer type, and water temperature. The authors note that identifying factors associated with VOC occurrence may aid in understanding the sources, transport, and fate of these compounds in groundwater. —**Tina Adler**



Of 2,401 wells assayed by Rowe et al., 1% had water containing VOCs above EPA maximum contaminant levels.

Drink a Toast to Tap Water

Study Suggests Water Consumption Benefit Outweighs THM Hazard

Many water treatment systems use chlorine to disinfect drinking water. However, chlorine reacts with dissolved organic matter in water to create trihalomethanes (THMs), which have been associated with excess risk of bladder cancer in people who drink chlorinated water. Now, in a large study conducted in Spain, an international team of scientists has examined the role of tap water and total fluid intake in bladder cancer risk, while also assessing the effect of exposure to THMs in water [EHP 115:1569–1572; Michaud et al.]. The results suggest that higher water consumption is associated with lower risk of bladder cancer, regardless of THM exposure.

Some studies have linked high consumption of fluids including tap water with a lower risk of bladder cancer, perhaps because urinating more frequently allows more flushing of the bladder. Other studies suggest that high tap water consumption could increase bladder cancer risk if chlorination by-products or other water contaminants such as arsenic are elevated in the water source. Adding to this complexity is that still other studies have shown a THM-related excess risk of bladder cancer in men but not women.

Between June 1998 and June 2001, researchers conducted a hospital-based case–control study of bladder cancer in multiple centers in Spain. Male and female bladder cancer patients aged 20–80 years were recruited from 18 participating hospitals. For the 397 bladder cancer cases available for this analysis, the team recruited 664 matched controls who had been admitted to the same hospitals around the same time for hernias, fractures, orthopedic problems, and other reasons.

Trained interviewers collected information during each subject's hospitalization that included sociodemographic characteristics, family history of cancer, smoking history, occupational history, residential history, drinking water source at each residence, beverage consumption (including water), and medical history. The researchers used local government and water company data on annual average THM levels, water source history since 1920, and chlorination



Drink up! Despite the potential for THM exposure, water is still a healthy choice of beverage.

history to calculate average year-by-year THM exposure. These data were available for 78.5% of the total study person-years.

The researchers examined the association between total fluid and water consumption and bladder cancer risk, while also examining the interaction between water intake and THM exposure. The results suggest that drinking more water, even from chlorinated sources with high THM levels, is beneficial in reducing risk of bladder cancer. The authors found a 53% lower risk of bladder cancer in people who drank 1,400 mL or more water per day compared with those who drank less than 400 mL per day after adjusting for known and potential confounders. This inverse association held across all strata of smoking status and THM exposure, and for both men and women.

The study was strengthened by high response rates from cases and controls, detailed interview data on individual beverage consumption, detailed assessment of THM exposure, and detailed data on smoking, which is believed to be the greatest risk factor for bladder cancer. —John Tibbetts

One–Two PM Punch

Gene Combination Increases Vulnerability to Air Pollutant

Numerous epidemiologic studies have found a link between exposure to fine particles ($PM_{2.5}$) and increased morbidity and mortality. Other studies have found evidence of some of the specific pathways through which this damage occurs, but much remains unknown about the relative importance of these pathways in humans. An international team of researchers has taken a step toward filling that void through its discovery that the combination of two genetic traits—a deletion of one gene and a polymorphism of another—combine to significantly increase risk of oxidative stress and subsequent cardiovascular disease in some people exposed to $PM_{2.5}$ [EHP 115:1617–1622; Chahine et al.].

One well-known indicator of potential cardiovascular problems is reduced heart rate variability (HRV). When the heart is less able to vary its beat, it can't respond as nimbly to challenges such as pollutants, microbes, or emotional stresses. $PM_{2.5}$ exposure has been linked with reduced HRV, possibly in part by triggering oxidative stress.

Several genes are known to play a role in defending against oxidative stress. Two of these include glutathione *S*-transferase-M1 (*GSTM1*) and heme oxygenase-1 (*HMOX-1*). To determine

whether these genes have a link with reduced HRV, the team studied 476 older Boston-area males, almost all white, for whom they had information on the two genes, as well as data for three established indicators of HRV: standard deviation of normal-to-normal intervals (SDNN), variation at high frequency (HF), and variation at low frequency (LF). Ambient $PM_{2.5}$ data came from a central station monitor, which had sampled in the 48-hour period prior to HRV testing and had earlier been shown to be a good proxy for personal exposures in the area. The team accounted for confounders such as age, body mass index, smoking, and prescription drug use.

Overall, they found that each $10\text{-}\mu\text{g}/\text{m}^3$ increase in $PM_{2.5}$ was associated with a statistically significant decrease in two measures of HRV (6.8% for SDNN and 17.3% for HF). Decreases for all three indicators were greater in men with either a *GSTM1* deletion or a particular polymorphism of *HMOX-1*. But the decreases were greatest in the men who had both the *GSTM1* deletion and the *HMOX-1* polymorphism, dropping 12.7% for SDNN, 27.8% for HF, and 20.1% for LF. This combination occurred in 48% of the subjects.

The researchers acknowledge that much more work needs to be done addressing variables such as sex, age, race, geographic setting, pathway of damage, and affected body system. But their findings lead them to conclude that at least one combination of genetic traits increases vulnerability to oxidative stress and cardiovascular damage from $PM_{2.5}$. —Bob Weinhold